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A COMING OF AGE:
The Implications of Precision Guided Munitions
for Air Power

by

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of the requirements for the degree of

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ABSTRACT

The thesis argues that air power now dominates modern warfare. The overwhelming victory of the Gulf War stands as a symbol of the maturity of air power. In effect, technology has caught up with nearly a century of air power theory, the early prophets of air power were basically correct. The air war in the Gulf was revolutionary in the sense that very few bombs were required to achieve an enormous amount of very focused, precise destruction. The existence of precision guided munitions allows single aircraft to accomplish what, in the past, would have taken literally thousands of aircraft to accomplish or could not have been accomplished at all. The argument is based on a comparison of the employment of air power in previous conflicts. A comparison is then made with the employment of air power in the Gulf War. In the context of modern war, the implications of the air war in the Gulf have profound implications for every warfare specialty. However this thesis only considers the implications of precision guided munitions for naval air power.

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EXECUTIVE SUMMARY

The overwhelming victory in the Gulf War stands as a symbol of the maturity of Air Power; it has come of age. The air war in the Gulf was revolutionary in the sense that very few bombs were required to achieve an enormous amount of very precise destruction. The existence of precision guided weapons allowed single aircraft to accomplish what, in the past, would have taken literally thousands of aircraft to accomplish or could not have been accomplished at all. The performance of precision guided munitions in the recent conflict suggests the following thesis: the technological advances have largely solved the problem of accuracy that prevented bombing alone from playing the decisive role in the past. Achieving precision accuracy and much improved target acquisition suggests that Air Power now dominates much of modern warfare.

Over the past 80 years the means to apply Air Power during a conflict has been strategic bombing. Concentrations of "strategic" bombers were originally considered the only way to achieve the desired strategic results. The central theme of this thesis is that this is no longer the case. Instead of bludgeoning an opponent through indiscriminate carpet bombing, we can now apply focused and discriminate force. Advanced conventional weapons with precision guidance allow air power to achieve strategic results quickly, effectively and economically. But no advance in technology yields an edge in

combat forever; responses will be found and effective countermeasures developed. Therefore, the United States must continue to develop and produce advanced conventional weapons and the systems that support them.

Just when the threats we have understood for decades appear to have diminished, the international security environment has entered a new, less stable phase. The future demands a comprehensive understanding of Air Power and its uses. In this regard, let me make it clear that "Air Power" is used in its most comprehensive sense. One thing is certain, Air Power will play a leading role in our response to future security challenges. It will in some circumstances be the only application of military power and in others will be the form on which successful surface and naval operations depend. In essence, air power now dominates nearly every military role and mission.

The thesis briefly reviews the employment of air power in previous conflicts. The experiences of the past provide a background for comparison with the Air War in the Gulf and reveals how precision accuracy alters the way in which we view air power. In particular it makes each and every tactical aircraft a potential strategic asset and targets normally reserved for strategic assets can now be destroyed by tactical assets. The implications of this fact transcend many levels of modern warfare, this thesis limits itself to exploring the impact of this new technology upon naval air power.

The primary advantage of precision guided munitions (PGM's) is they can destroy a target with a minimum of weapons. In essence they exploit the economy of force maxim of warfare. The importance of this fact is very relevant to naval air power. PGM's question the reasons why naval air power is not considered an integral portion of any strategic air campaign. Naval air power, both cruise missiles and naval tactical aviation, can make an important contribution to any future bombing campaign; in some cases it may be the only way to get the job done.

I. INTRODUCTION

Until recently, the history of Air Power has been characterized by exaggerated claims. The stunning results of the Gulf War indicate that modern Air Power may at last have the capabilities claimed for so long. The performance of precision guided munitions suggest the following thesis: the technological advances have largely solved the problem of accuracy that prevented bombing alone from playing the decisive role in the recent past. The achievement of precision accuracy and much improved target acquisition suggests that Air Power now dominates much of modern warfare.

The overwhelming victory in the Gulf War stands as a symbol of the maturity of Air Power; it has come of age. The Air War in the Gulf was revolutionary in the sense that very few bombs were required to achieve an enormous amount of very focused, precise destruction. The existence of precision guided weapons allowed single aircraft to accomplish what, in the past, would have taken literally thousands of aircraft to accomplish or could not have been accomplished at all.

Just when the threats we have understood for decades appear to have diminished, the international security environment has entered a less stable phase. The future demands a comprehensive understanding of Air Power and its uses. In that regard, let me make it clear that I use the

term "Air Power" in its most comprehensive sense. I submit that air power will play a leading role in our response to future security challenges. It will in some circumstances be the only application of military power and in others it will be the form on which successful surface and naval operations depend. In essence, air power now dominates nearly every military role and mission.

A. THESIS

The early prophets of air power--notably General Giulio Douhet (1869-1930), General William Mitchell (1879-1936), and Air Marshal Hugh Trenchard (1873-1956)--based their visions on the very limited air power experience of World War I. Their visionary reach exceeded their technological grasp by many decades. As a result they seemed to promise quick, cheap victories from the air. This was certainly true of General Douhet, who insisted that achieving "command of the air" would not only be necessary but also sufficient for victory.¹

The first conflict that saw the employment of air power on a large scale, World War II, tempered the views of its advocates. Shortcomings in both technology and combat experience meant that victory in WWII came neither quickly nor

¹This central theme is expressed in David MacIsaac, "Voices From the Central Blue: The Air Power Theorists," in Makers of Modern Strategy: From Machiavelli to the Nuclear Age, ed. Peter Paret (Princeton, New Jersey: Princeton University Press, 1986), pp. 624-647.

cheaply. The many assumptions and promises of the air power prophets fell short. As a result many came to view air power theory as a series of unrealized, and perhaps unreachable, dreams. However, recent experience suggests that perhaps the early air power prophets were basically correct.

General Douhet established a primary tenet of air power that has remained constant over the years. He considered the guiding principle of any bombing actions should be this:

the objective must be destroyed completely in one attack, making further attack on the same target unnecessary.²

This tenet was originally interpreted as the delivery of large amounts of munitions against a target to ensure its destruction. Many technological shortcomings, such as limited carrying capacity, precision navigation equipment, and weapons accuracy, existed in air power's early years that required this solution.

Over the past 80 years the means to apply Air Power during a conflict has been strategic bombing. Concentrations of "strategic" bombers were originally considered the only way to achieve the desired strategic results. The central theme of this thesis is that this is no longer the case. Instead of bludgeoning an opponent through indiscriminate carpet bombing, we now can apply focused and discriminate force. Advanced conventional weapons with precision guidance allow air power

²Charles M. Westenhoff, Military Air Power: The CADRE Digest of Air Power Opinions and Thoughts, (Maxwell Air Force Base, Alabama: Airpower Research Institute, 1990), p. 50.

to achieve strategic results quickly, effectively and economically. But no advance in technology yields an edge in combat forever; responses will be found and effective countermeasures developed. Therefore, the United States must continue to develop advanced conventional weapons and the systems that support them.

A brief review of air power history is in order to develop this argument. The experiences from the past provide a background for comparison with the Air War in the Gulf. Precision accuracy has fundamentally altered the way we view air power. In particular it makes each and every tactical aircraft a potential strategic asset. Targets normally reserved for strategic assets can now be destroyed by tactical assets. The implications of this fact are profound and transcend many levels of modern warfare. This thesis is limited to exploring the impact of this new technology upon naval air power. At the outset a few definitions are required to provide a common frame of reference.

B. DEFINITIONS

1. Precision Guided Munitions

The term precision guided munitions applies to the complete weapon system based on technologies such as sensors, munitions, advanced information systems, target acquisition systems, communications systems, and missile defense. For this purpose it will refer to extended-range cruise missiles

and guided munitions of great precision, discrimination, and control, that possess a near-zero circular error probable (CEP).³

While improved accuracy is required to fulfill the definition of an advanced conventional weapon, there also must be sufficient destructive capability in the warhead to ensure a high probability of kill. This is accomplished through several technologies that already exist, or are on the horizon.⁴

2. Strategic Conflict

The term strategic conflict is defined by its scope. Carl Builder suggests that the most helpful definition for strategic conflict comes from Webster's dictionary in which it is warfare designed "to strike at an enemy at the sources of his military, economic or political power."⁵ the thrust of the overall war effort.

³Circular Error Probable (CEP) - the radius of the circle around the intended target within which there is a 50 percent probability that a weapon aimed at the target would land within.

⁴for a more detailed description on precision guided munitions and the basics of their operation, I suggest the following publication: R. J. Heaston and C. W. Smoots, Introduction to Precision Guided Munitions, GACIAC HB-83-01 Vol 1, (Chicago, Illinois: Guidance and Control Information Analysis Center, 1983).

⁵Webster's New Collegiate dictionary, (Springfield, Massachusetts: Merriam, 1981), 1141, in Carl Builder, "The Prospects and Implications of Non-nuclear Means for Strategic conflict," Adelphi Paper 200, (London: International Institute for Strategic Studies, 1985), p. 2.

3. Center of Gravity

The term center of gravity is useful in planning any operations during a conflict. Clausewitz considered the center of gravity to be the "hub of all power and movement."

It describes that point where the enemy is most vulnerable and point where the attack has the best chance of being decisive or a specific point where a level of effort can accomplish more than that same level of effort could accomplish if applied elsewhere.⁶

C. SUMMARY

The issue is whether we have entered a new era in which bombing can determine who will win the war. Today after 80 years of experience extending across the spectrum of conflict and some stunning technological developments air power dominates modern warfare. If so, modern technology may have caught up with nearly a century of air power theory with profound implications for the future of warfare.

Current technologies allow for the production of highly accurate and relatively inexpensive extended range weapons. The difficulty is that in the current era of fiscal constraints our political leaders may decide otherwise. The

⁶The term "center of gravity" is drawn from John A. Warden, The Air Campaign: Planning for Combat, (Washington D.C.: National Defense University Press, 1988), pp 9-11.

implication is that new technologies are not likely to be vigorously pursued because of budgetary concerns.

However, decision makers inclined to reduce or eliminate financial support for sophisticated advanced conventional munitions systems and technology should first appreciate the following:

1. Surface forces have great difficulty operating in the face of strong, hostile air power.

2. In what has been called the low intensity conflict environment, air power provides advantages for surface forces engaged in guerrilla tactics. Specifically these advantages are mobility, aerial reconnaissance, and quick-response firepower.

3. Modern navies have capitalized heavily on the strength of naval air power with the aircraft carrier and the new role of surface ships armed with cruise missiles. In a conventional war, only air power can be rapidly applied simultaneously to every type of target, whether strategic, operational or tactical.

The existence of advanced conventional weapons underscores these points. In truth, we are only beginning to understand how air power with advanced conventional weapons affects modern warfare. None of this should be taken to deny the importance of surface and naval forces for whom many tasks remain. Air power cannot occupy territory or maintain a continuous forward presence without a base in close proximity. However, air power does possess tremendous leverage that creates conditions for our forces to fight by denying the enemy not just battle and campaign choices, but whole strategies.

II. A LOOK AT THE PAST

A sense of history is an essential element in the strategic thought for several reasons. First it prevents one from viewing war in isolation and demonstrates the relationship between war and those political, economic, social and intellectual considerations that permit war. Second, history strengthens critical judgment with its wealth of empirical evidence. In particular, the historical context of air power's role in the spectrum of combat is necessary to provide a contrast with the recent employment of air power in the Gulf War and highlights the amazing impact of precision guided munitions.

This chapter illustrates the nature of air power prior to precision guided weapons. There are numerous books and articles on the effectiveness of past strategies designed to apply air power during a conflict; no attempt to argue this point is made here. Instead, the historical problem of translating strategy into employment and their associated weapon systems will be investigated. Of particular importance, the introduction of precision guided munitions in Vietnam heralded their impact in the Gulf War. The linkage between strategy and weapons is of prime importance in this thesis.

A. AN HISTORICAL PERSPECTIVE

The doctrine for strategic air attack was already firmly established before World War II. During the period between 1920 and 1941, U.S. military planners formulated a doctrine based on the premise that neutralization of an enemy's industrial base would destroy the will and means of the enemy to wage war.

The Army Air Corps Tactical School was the focal point for the development of strategic bombardment doctrine during the period. Originally, the school was founded in 1920 with the title of Air Service Field Officer's School. After a change in name, a move, and a change in scope, it became the Air Corps Tactical School at Maxwell Field, Alabama in 1931. Some of the first students at the school were Ira C. Eaker, Carl Spaatz, Curtis Lemay, Haywood Hansell and Claire E. Chennault. These men would become central figures in the development and employment of air power in war.

The school went through many steps in the development of a doctrine to employ air power. The initial work was heavily influenced by the experience of World War I and by a very outspoken advocate of air power, General "Billy" Mitchell. By 1930, the school's central theory, known as the strategic bombardment doctrine, included a premise that was to last throughout World War II. Specifically the premise was that bomber formations could concentrate enough firepower on a given target to overcome the limitation in accuracy of early

aircraft and provide sufficient self-defense against hostile aircraft.

The theory of strategic bombardment developed during the 1930's included the following:⁷

1. Accurate strategic bombing favored daylight operations. Daylight would improve bombing accuracy because it would allow large aircraft formations and would reduce the navigation problem.

2. Attacks should be from high altitude. Low altitude treetop-level bombing was considered as a means to reduce detection by hostile aircraft but was rejected because of navigational problems.

3. Attacks should be against the national economic structure to reduce the will and ability of the enemy to fight. The targets included:

- refineries
- electric power facilities
- aircraft industrial facilities
- steel industry
- transportation systems
- sources of raw materials⁸

The strategic bombardment doctrine did not require the complete destruction of the above targets. The official statements from the tactical school on the objectives of any strategic bombing campaign clarify the point:

It must be remembered that disorganization...rather than complete destruction is the ultimate aim of the Air

⁷Haywood S. Hansell, Jr., The Air Plan That Defeated Hitler, (Atlanta, Georgia: Higgins-McArthur, 1972), pp. 41-48.

⁸Bombardment Text, Air Corps Tactical School, Maxwell Field, Alabama, 1935, pp. 49-76.

Force...disorganization is the aim because it is more economical and is equally effective.⁹

The tactical school also developed a probability concept to determine how many bombs would be required to destroy the target sets. The results of peacetime bombing competitions were used to determine an appropriate force composition to achieve a 90 percent probability of destruction. The use of the concept had obvious limitations. The biggest assumption was that the accuracy achieved in peacetime exercises could be maintained in a combat environment. It was not until the experience of actual combat was this assumption altered, but the concept set the stage for the use of mathematical techniques to calculate a target's probability of destruction; these techniques made the importance of accuracy dramatically clear.

B. WORLD WAR II

In July 1941, President Franklin D. Roosevelt expressed concern that the quantity of available weapons might be inadequate to execute our doctrine in wartime. He directed Secretary of War Henry Stimson to determine the overall production requirements needed to defeat our potential

⁹The Air Force, Air Corps Tactical School, Maxwell Field, Alabama, 1932-1933, p. 7.

enemies.¹⁰ The War Department utilized the experience located in the Air Corps Tactical School to develop an employment doctrine for Air Power in a war. The doctrine was articulated in the Air War Plans Division (AWPD) document, which became known as AWDP-1.

Developing the doctrine was a massive undertaking for the drafters of AWDP-1. The drafters of the document made some basic assumptions on the accuracy of the weapons, the number of weapons required to destroy a given target and an estimate of aircraft loss rates. These assumptions were gleaned from the limited American combat experience in the application of air power in World War I. However, the more recent combat experience of our Allies did influence the creation of AWDP-1. The following are the results of this early plan designed to guide the application of air power in the upcoming war:

1. The planners used July 1943 as the time period for the start of operations. A final all out attack was scheduled for some time between April and September of 1944.
2. The targets included 154 separate types that included electric power systems, transportation sites, petroleum sites, aircraft assembly plants and many others. An interesting note is that electrical power sites were considered the primary target.
3. The drafters established a requirement of 220 100 pound bombs to destroy a 100 square-foot target.
4. A heavy bombardment group consisted of 70 aircraft. The recent combat experience of the Royal Air Force suggested that bombing errors in combat conditions were 2.25 times

¹⁰Russell F. Wrigley, The American Way of War: A History of United States Military Strategy and Policy, (Bloomington, Indiana: Indiana University Press, 1977), pp. 333-336.

greater than peacetime bombing. The limitation in accuracy meant 30 bomber groups were necessary to destroy a target. The equation was applied to all targets using only eight suitable weather days per month for daylight visual bombing in a six-month period. As a result the Air Doctrine calculated that 6,860 bombers were necessary for the bombing effort.¹¹

The drafters of AWDP-1 were convinced of the merits of air power. They enthusiastically stated that if the air offensive was successful, a land invasion might not be necessary.¹² The implicit hope for air power was that it offered a revolutionary way of winning the war. The bold air plan was submitted to Army Chief of Staff General George C. Marshall who quickly approved and forwarded the document to the President.

In late 1942, based on actual combat experience, the AWDP-1 was updated. The new document was the AWDP-42 and was similar to the previous plan. Air power still was the key to operations against Germany. It called for a conclusive strategic offensive against the Axis powers and for a strategic defensive against Japan in the Far East. AWDP-42 differed from its predecessor in two ways. It combined Army Air Force (AAF) and Royal Air Force (RAF) operations into a single offensive strategy and broadened the target set. The

¹¹Air War Plans Division-1, Munitions Requirements of the Army Air Forces (12 August 1941), Part 2, tab 1, 2, 2b. (Hereafter referred to as AWPD-1.)

¹² AWDP-1, part 2, tab 1, p. 2.

document defined the different missions of the AAF and the RAF as:

The U.S. Army Air Force will concentrate its efforts upon systematic destruction of selected vital elements of the German military and industrial machine through precision bombing in daylight. The R.A.F. will concentrate upon mass air attacks of industrial areas at night, to break down morale.¹³

The target list specified in the AWPDP-42 placed more emphasis upon the destruction of the German U-boat threat and the Luftwaffe. The targets in priority order included pursuit airplane assembly plants, bomber airplane assembly plants, aeroengine plants, submarine yards, transportation sites, and power generating sites.¹⁴

The new target set forced a revision of the force structure required to ensure destruction. AWPDP-42 established a requirement for 2,965 bombers and, in contrast to AWPDP-1, called for a fighter escort. The planners used a bombing accuracy of 1,000 feet for circular error probable (CEP) to calculate the force requirements. The planners felt that for the 177 identified targets 136,500 tons of bombs would be delivered on 66,045 sorties by the 2,965 bombers.¹⁵ The biggest assumption made by the AWPDP-42 was that the force

¹³Air War Plans Division-42, Requirements for Air Ascendancy (9 September 1942), Part IV, p. 2. (Hereafter referred to as AWPDP-42.)

¹⁴AWPDP-42, Tab B-1-a.

¹⁵Ibid.

requirement could be maintained regardless of the rate of attrition.

In November 1942 the Casablanca Conference changed the Allied plan for strategic bombing. The overall goal of the air offensive became the progressive destruction and dislocation of the German military, industrial, and economic system and the undermining of the morale of the German people to a point where their capacity for armed resistance was fatally weakened.¹⁶

The Casablanca Conference also changed the priority of the targets for the air offensive, they were directed in order of priority:

1. German submarine construction yards
2. The German aircraft industry
3. Transportation
4. Oil plants
5. Other targets in the enemy war industry¹⁷

However, the Casablanca agreements on target priority were not the final determination of what targets, how many aircraft and what accuracy of weapons should be used in planning for the strategic bombing offensive.

¹⁶Russell F. Wrigley, The American Way of War: A History of United States Military Strategy and Policy, p. 338.

¹⁷Thomas A. Fabyanic, Strategic Air Attack in the United States Air Force: A Case Study, (Manhattan, Kansas: Military Affairs/Aerospace Historian Publishing, 1976), p. 75.

Instead, a committee of operational analysts made a study of the German economy and, using the political guidance of the Casablanca Conference, made a target list recommendation.¹⁸ The list was combined with the AWDP-42 and the final target list was made for the combined bomber offensive. The analysts and planners identified targets were considered the "key vital centers" of the German War effort, these targets were, in order of priority:

1. Intermediate Objective: German fighter strength
2. Primary Objectives: German submarine yards and bases, the remainder of the German aircraft industry, ball bearing plants, oil production sites
3. Secondary Objectives: synthetic rubber and tire production sites and military motor transport vehicles¹⁹

The target list contained 76 actual targets and required a force of 2,702 bombers.²⁰ The importance of this new target set was that its objective was air supremacy. The goal of air supremacy marked a major modification to air power doctrine. The strategists did not accept Douhet's idea that a contest for air supremacy was not necessary.²¹ Actual combat experiences identified the nature of the problem. The

¹⁸Ibid, p. 78.

¹⁹Wrigley, The American Way of War: A History of United States Military Strategy and Policy, p. 337.

²⁰Fabyanic, Strategic Air Attack in the United States Air Force: A Case Study, p. 80.

²¹Wrigley, The American Way of War: A History of United States Military Strategy and Policy, p. 334.

effectiveness of the German Air Defense indicated that the bomber would not always get through. Long-range fighters were necessary to counter the threat of German fighters. The result was planners recognized the need for rival fighters to struggle for command of the air.

The significance of the strategic bombing attacks on the German industrial base is reflected by Albert Speer's comments thirty years later:

I shall never forget the date May 12 [1944]...On that day the technological war was decided. Until then we had managed to produce approximately as many weapons as the armed forces needed, in spite of their considerable [equipment and personnel] losses. But with the attack of nine hundred and thirty-five daylight bombers of the American Eighth Air Force upon several fuel plants in central and eastern Germany, a new era in air war began.²²

German industrial production could no longer fully support the war effort. The air offensive had made a difference.

The lessons of the strategic bombing campaign against Germany are reflected in the report by the United States Strategic Bombing Survey (USSBS). The report made these general observations:

full scale strategic bombing directed at the heartland of any major power, even one as rugged and resilient as Germany's, could be decisive...Regardless of the forces actually applied, the USSBS concluded that persistent re-attack of all targets was necessary since no target system had been put out of commission by a single attack.²³

²²Albert Speer, Inside the Third Reich, (New York: The Macmillan Company, 1970), p. 346.

²³Fabyanic, Strategic Air Attack in the United States Air Force: A Case Study, p. 95.

The technology available during World War II created the requirement to re-attack targets; the fundamental limitation was the lack of precision accuracy.

C. THE STRATEGIC AIR CAMPAIGN AGAINST JAPAN

The initial phases of the war against Japan were purely defensive. The Allies agreed to make the defeat of Germany the primary objective of the overall war effort. By the time the war in the Pacific shifted to an offensive one, the doctrine of strategic bombing and its associated weapon systems incorporated several refinements.

The U.S. strategic air war in Europe was fought primarily with the B-17, whereas the strategic war against Japan used the more modern and capable B-29. The USSBS provides other comparisons between the European and Pacific strategic air campaigns.

The physical destruction resulting from the air attack on Japan approximates that suffered by Germany, even though the tonnage of bombs dropped was far smaller. The attack was more concentrated in time, and the target areas were smaller and more vulnerable. Not only were the Japanese defenses overwhelmed, dispersal and passive defenses were less than Germany's. In the aggregate some 40 percent of the built-up area of the 66 cities attacked was destroyed. Approximately 30 percent of the active urban population of Japan lost their home and many of their possessions. The physical destruction of industrial plants subjected to high-explosive attacks was similarly impressive. The larger bomb loads of the B-29 permitted higher density bombs per acre in the plant area, and on the average,

somewhat heavier bombs were used. The destruction was generally more complete than in Germany.²⁴

The targets struck by the B-29's in Japan were similar to those in Europe. The Joint Targeting Group in Washington suggested the rationale behind the selection of targets. It states that:

there were no strategic bottlenecks in the Japanese industrial and economic system except aircraft engine plants, but...the enemy's industry as a whole was vulnerable through incendiary attacks on the principal urban areas.²⁵

The priority targets were engine manufacturing plants, followed by four aircraft component and assembly plants. Port and urban industrial areas were designated as secondary targets.

The Allies planned for a strategic air attack to reduce the will of the Japanese. The incendiary raids on Japan were specifically designed to accomplish this objective. The civilian deaths attributed to the incendiary raids proved staggering. The bombing survey reported that:

[civilian deaths] exceeded the number of strictly military deaths inflicted on the Japanese in combat by armed forces of the U.S. ... more persons were killed in one 6-hour period by the least expenditure of bombs than in any other recorded attack of any kind.²⁶

²⁴The United States Strategic Bombing Survey (Pacific War), Report no. 1, p. 17. (Hereafter referred to as USSBS.)

²⁵Wesley Craven and James Cate, eds., The Air Force in World War II, (Chicago: University of Chicago Press, 1953), vol. V. p. 624.

²⁶USSBS (Pacific War), Report no. 90. p. 2.

In March, 1945, the most destructive conventional air raid in history was conducted against Tokyo. In loss of life, it killed 83,793 people, injured 40,918, destroyed a quarter of Tokyo's buildings, and left more than a million people homeless.²⁷ The Allies wanted to bring Japan to surrender without having to resort to a invasion, the objective was to end the war quickly and keep their casualties to a minimum. It is interesting to note that the casualties of this conventional attack compare in magnitude to either the casualties from the use of atomic weapons at either Hiroshima or Nagasaki. In retrospect, the use of atomic weapons was the logical next step in the strategic bombing offensive.

D. WORLD WAR II WEAPON SYSTEMS

A brief description of the aircraft employed in the strategic bombing campaigns of World War II is a requirement for the reader to understand two important points. The first is the dramatic improvements that have occurred through numerous technological advances made over Air Power's history. The other point is Airmen have continually looked for innovations to improve accuracy. The implication is that the technology resident in today's advanced conventional weapons reflect the end of an 80 year search for accuracy and the evolution of technology.

²⁷Wrigley, p. 364.

The main weapon system for the U.S. bombing offensive against Germany was the B-17 Flying Fortress. The initial models of the aircraft did not have enough defensive armament to be a true "Flying Fortress." By the end of 1941, numerous improvements were incorporated into the B-17G. The improved model had a top speed of 300 mph at 30,000 feet, an armament of 13 .50-caliber machine guns and could carry up to 17,600 pounds of gravity bombs for short ranges or 4,000 pounds for long ranges. The B-17G was superior to the best British and German bombers of the time.²⁸

A clear example of wartime experience, strategy, and operational requirements leading to a weapon system is the development of the Boeing B-29 Superfortress. The design of this aircraft reflects the doctrine of strategic bombing by high-altitude heavily armed bombers. The armament of the B-29 included four remote-controlled turrets each containing two .50-caliber machine guns and a direct-controlled tail turret containing two .50-caliber machine guns and a 20mm cannon. The major improvement over the B-17 was that the B-29 could carry a larger payload to a greater distance. The aircraft could carry up to 16,000 pounds of bombs to a maximum range of 5,830 miles.²⁹

²⁸John Kirk and Rober Young, Jr., Great Weapons of World War II, (New York: Walker and Company, 1961), pp. 72-75.

²⁹Ibid, pp. 122-135.

During the course of the war the incorporation of a technological innovation suggests U.S. airmen actively desired a way to increase the accuracy of the existing systems. In the Pacific theater, improvements in radar allowed strategic precision bombing to be conducted at night or in all-weather conditions. General LeMay made the following observation after reviewing the results of a radar directed mission:

I have just reviewed the post-strike photography of your strike on target 1764, the Maruzen Oil Refinery at Shimotsu, the night of 6/7 July. With a half-wing effort you achieved ninety-five percent destruction, definitely establishing the ability of your crews with the APQ-7 [the radar] to hit and destroy precision targets, operating individually at night. The performance is the most successful radar bombing of the command to date.³⁰

During the European strategic bombing offensive, daylight precision bombing required clear weather and good visibility for the Norden optical bombsight to work. The introduction of radar on the B-29 provided the means to give the Allies a more precise strategic bomber.

The search was definitely on to increase bombing accuracy. The results did not achieve anything close to near zero CEP. However, before the development of precision guided munitions another answer became available. Instead of destroying a target with a direct impact, the ability to deliver an enormous destructive blast on a target presented itself.

³⁰Haywood S. Hansell, Jr., Strategic Air War Against Japan, (Maxwell AFB, Alabama: Airpower Research Institute, 1980), p. 63.

E. THE INTRODUCTION OF NUCLEAR WEAPONS

The atomic bomb attacks on Hiroshima and Nagasaki are perhaps the most publicized of the strategic bombing attacks of the war. The weapons marked a revolutionary increase in the destructive potential of air power. From a strategy to weapon standpoint, they were a logical development in the doctrine of strategic bombing. However kind or unkind history is to the first and only use of nuclear weapons, they do mark a long period of stagnation in the evolution of U.S. strategic thought on air power.

The issue of whether the use of atomic weapons induced the Japanese to surrender is a widely debated topic. The conclusions of the USSBS indicate the nature of the issue:

From the standpoint of the politics of surrender--and by August 1945 politics was the key--the atom bombing of Hiroshima and Nagasaki was not essential. From its studies of Japanese resources, military position, and ruling class politics, the survey estimates that the government would have surrendered prior to 1 November and certainly before the end of the year, whether or not the atomic bombs had been dropped and Russia had entered the war. In the 10 to 15 weeks between the actual and probable surrender date, the air attack from the Marianas, augmented by the Okinawa-based forces, would have reached a new high. Furthermore, morale probably would have continued its already steep decline to complete demoralization. The atom bombs hastened surrender, but did not themselves provide the major motive.³¹

Clearly, the use of atomic weapons provided the Japanese an added incentive to surrender, they were not the sole reason. Nuclear weapons may not have been instrumental during World

³¹USSBS (Pacific War), Report no. 14, p. 4.

War II, but they did play a major role in shaping the post-war international environment.

Strategic bombing, the contemporary embodiment of air power, could now cripple a country's war effort with either conventional or nuclear weapons. As long as the U.S. held a monopoly on atomic weapons it enjoyed a remarkable advantage. However, the U.S. lost this luxury once the Soviet Union attained a nuclear capability. Air power now had two faces, a nuclear one and a conventional one. The juxtaposition of the two created a period of stagnation in air power thought and doctrine as its advocates struggled to deal with the enormous destructive qualities of atomic weapons.

The theme of U.S. strategic bombing during World War II had been to limit civilian casualties whenever possible. The introduction of atomic bombs eliminated the distinction between military and civilian targets. Nuclear weapons were simply too powerful for pinpoint attacks. Collateral damage to civilians would unavoidably occur in any strategic bombing campaign using nuclear weapons. Nuclear weapons created a dilemma for U.S. air power advocates.

The incorporation of atomic weapons into Air Power created a deterrent strategy that prevails even today. This thesis affected the proper employment of air power in the two major conflicts of the Cold War. The threat of a larger conflict or a nuclear exchange affected the employment of air power in both Korea and Vietnam.

F. THE KOREAN WAR

The results of Air Power against North Korea are somewhat confusing but in the aggregate can be considered successful. The strategic bombing campaign in Korea began in August of 1950 but only lasted eight weeks. The Joint Chiefs of Staff determined:

that destruction of such targets of relatively long-term military significance was no longer considered necessary. Hence forward, all air operations were to be directed against objectives which had an immediate bearing upon the tactical situation in Korea.³²

Strategic air operations were terminated on 27 September 1950 and for the remainder of the war air power was employed to interdict the North Korean military.

Originally, military planners compiled a priority listing of strategic targets. The targets were assigned by area rather than a specific target set. Most of the targets were close together and required only a minimum number of missions. The plan called for incendiary raids against the target areas followed by demolition bombs in precision attacks against industrial plants.³³ The Joint Chiefs of Staff approved the plan, but

Washington was very hesitant about any air action which might be exploited by Communist propaganda and desired no

³²Robert Frank Futrell, The United States Air Force in Korea 1950-1953, (New York: Duell, Sloan and Pearce, 1961), p. 158.

³³Ibid, p. 176.

unnecessary civilian casualties which might result from fire raids.³⁴

The threat of escalation to a larger scale conflict prompted the U.S. political leadership to restrict the use of air power in Korea.

The initial attacks were heavy and targets were hit until destroyed. B-29's from the Far East Air Forces (FEAF) faced little opposition as they bombed North Korean transportation and industrial centers. The bulk of target selection was given to the FEAF's Target Committee which was the "basic theater agency for target selection."³⁵ The Target Committee focused first on the North Korean industry and directed attacks against the North Korean facilities in Hungnam, Wonsan, Pyongyang, and Konan. However, North Korea's major hydroelectric power plants along the Yalu river were deliberately not targeted.³⁶

In the end, U.S. strategic bombing in Korea followed post-World War II conventional bombing doctrine closely. One point became evident, strategic bombers could use conventional weapons to interdict an opponents military infrastructure. However, the use of air power in the Korean conflict was not

³⁴Ibid, pp. 178-179.

³⁵From excerpts of the Far East Air Forces (FEAF) Report on the Korean War, 25 June 1950-27 July 1953, Vol. II in R. F. Futrell, The United States Air Force in Korea, 1950-1953, pp. 190-192.

³⁶Ibid.

considered its primary role. Instead, the emphasis remained on the potential for a nuclear conflict. The importance of this is that consequently little effort was placed on improving conventional capabilities.

G. THE SECOND USE OF AIR POWER IN THE NUCLEAR AGE

The Vietnam conflict (1965-1973) in Southeast Asia was the second large scale U.S. employment of air power in the nuclear age. The strategic bombing campaign in Korea came at the start of hostilities while in Vietnam it came at the end, after a long intermittent aerial interdiction campaign. In Vietnam military doctrine was subordinated to a policy of "coercive bargaining," where force and the threat of greater force were used as forms of political pressure as signals of intent, Rolling Thunder provides an example. Political leaders constrained the effective use of air power in both Vietnam and Korea.³⁷

The effectiveness of air power in Vietnam must be viewed in the light of the self-imposed restrictions on its employment. The restrictions were designed to prevent direct Soviet or Chinese intervention that could have turned the limited war into a direct confrontation between superpowers.

³⁷The basic ideas for this section are heavily influenced by Mark Clodfelter, The Limits of Airpower: The American Bombing of North Vietnam, (London: Collier-Macmillan, 1989).

The net result was to dilute the potency of the air campaign, turning it into a war of attrition against the North Vietnamese.

During the war, the U.S. conducted two distinct bombing campaigns, Rolling Thunder and Linebacker. In both, the B-52 was the primary aircraft used to deliver large quantities of ordnance. The primary role of the B-52 was not strategic but rather interdiction.

1. Rolling Thunder

President Johnson's approval for air strikes against Vietnam in February 1965 began the first attempt to employ air power in Vietnam for a strategic effect. On 24 February, Operation Rolling Thunder, a major interdiction campaign characterized by gradually increasing the use of force, began a nearly four year run.

The ominous name came as cells of B-52 bombers carpet bombed acres of terrain in an effort to knock out supply caches and suspected locations of North Vietnamese troops. Secretary of Defense McNamara provided the rationale for the use of B-52s against these targets:

We are faced with very, very heavy jungle in certain portions of South Vietnam, jungle so heavy that it is impossible to find an aiming point in it. We know some of these jungles are used by the Viet Cong for base camps and for storage areas...you can imagine that without an ability to find an aiming point, there is only one way of bombing it and that is with a random pattern...and I believe this was a proper use of the weapons [and] that

these strikes would destroy certain of the Viet Cong based areas...there is no other way of doing it.³⁸

Initially, the Rolling Thunder campaign was limited to targets south of the 20th parallel. The target selection process was much different from that used in either World War II or Korea. No longer did the senior staff debate the priorities of strategic targets. Instead,

Washington still had reservations and placed severe controls on B-52 employment. One such control called for approval in Washington, sometimes at the White House level, of all proposed targets.³⁹

Only targets on a list prepared by the Joint Chiefs of Staff and approved by the Secretary of Defense and the President could be hit. Additionally, the bombers were restricted from attacking ports and industrial plants.⁴⁰ The acceptable target lists did not allow air commanders any leeway. In effect the constraints removed one of air power's greatest advantages, its flexibility.

In the middle of March, 1965, Washington loosened the restrictions. The approval was given for strikes into North Vietnam itself, but the control over the lists of permissible targets remained in Washington. Additionally, special restrictions prevented air commanders from attacking any

³⁸Carl Berger, ed., USAF in Southeast Asia, (Washington D.C.: Office of Air Force History, 1977), p. 149.

³⁹Ibid, pp. 149-150.

⁴⁰Lon O. Nordeen, Jr., Air Warfare in the Missile Age, (Washington, D.C.: Smithsonian Institution Press, 1985), p. 11.

target within 30 miles of Hanoi, within 10 miles of Haiphong or within 30 miles of China. Throughout the air campaign the president not only determined where and what his pilots could attack but also how often they could do so.⁴¹

Even with the targeting constraints, the effectiveness of the B-52 during rolling thunder was demonstrated on several occasions. General William C. Westmoreland provides one such example when several months after the battle of Khe Sanh he observed,

the thing that broke their back basically was the fire of the B-52s...the heavyweight of firepower, was the tremendous tonnage of bombs dropped by our B-52s.⁴²

The air campaign did affect the outcome of tactical situations, but on the strategic level it was a failure.

Vietnam is a country whose greatest resources are its people and their food supply. The difficulty for Rolling Thunder is that it did not attack the correct types of targets effectively. For the typical North Vietnamese, Rolling Thunder was more a nuisance than a danger. Few consumer goods other than food arrived in the North, and throughout the air campaign the average daily intake of calories fell from 1,910 in 1963 to 1,880 in 1967.⁴³ Although Rolling Thunder affected the North Vietnamese, they quickly responded with a

⁴¹Mark Clodfelter, The Limits of Airpower, pp. 118-124.

⁴²Carl Berger, ed., USAF in Southeast Asia, p. 150.

⁴³Mark Clodfelter, The Limits of Airpower, p. 137.

stoic determination. Additionally, after a short period of time the North Vietnamese knew that President Johnson would not allow the use of unrestricted air power against their country.

Rolling Thunder gradually grew more severe, reflecting the movement of the debate among the president's advisors over the value of bombing North Vietnam. By the end of 1967, most of North Vietnam's major electric power and industrial targets were bombed. U.S. aircraft routinely fought their way into and back out of North Vietnam's airspace. North Vietnam's government, in response, dispersed its petroleum supplies and constructed more air raid shelters.⁴⁴ The response to the air campaign enabled North Vietnam to tolerate the damage from Rolling Thunder.

President Johnson announced on March 31, 1968 that the United States would cease all bombing north of the 20th parallel. Several factors influenced the president to make this decision; the increasing numbers of U.S. casualties to an increasingly effective North Vietnamese air defense network, the Tet offensive and political turmoil in the United States. The essential fact is that Rolling Thunder ended without having achieved any strategic result.

⁴⁴Ibid, p. 138.

2. Linebacker

On 30 March 1972, regular units of North Vietnam's army attacked across the declared demilitarized zone. In response, President Nixon ordered the Joint Chiefs to make preparations for air strikes into North Vietnam. The most crucial task of U.S. air power was to slow the North Vietnamese invasion.

Once enough assets were available, aircraft began to interdict supply and transportation networks. A crucial difference distinguishes Linebacker from Rolling Thunder. Washington relaxed its controls over the conduct of operations, most of the targets on the original Joint Chiefs target list were released, and commanders had the freedom to choose when, where, and how frequently to attack a target.⁴⁵ The authority to strike almost any valid military target was in sharp contrast to the extensive restrictions in existence during Rolling Thunder.

Linebacker lasted from April through December of 1972. On 16 April, B-52s and other aircraft bombed the oil storage facilities near Haiphong and on 8 May, Navy aircraft mined and closed the port of Haiphong. By the end of May, most of the crucial rail lines linking China to Hanoi and Haiphong had

⁴⁵Ibid, p. 164.

been cut. North Vietnam's imports of material were cut to less than one fifth of what they were before Linebacker.⁴⁶

Linebacker I achieved in its first four months of operation what Rolling Thunder had been unable to do in three and a half years. B-52s participating in Linebacker conducting both strategic and interdiction missions, but assessing their impact is beyond the scope of this paper. However we shall review another key element contributing to the campaign's success, the use of tactical aircraft with precision guided munitions.

The Air Force and Navy successfully employed two newly developed precision guided weapon systems, laser-guided bombs (called Paveway) and an electro-optically guided glide bomb (called Walleye). The type of target being attacked determined the type of weapon used against it. Against area targets such as railroad yards and storage facilities, where the risk of civilian casualties was minimal, conventional bombs were used. Using laser or electro-optical guidance technology developed after Rolling Thunder, the new precision weapons could hit targets in populated areas with remarkable accuracy and minimize collateral damage.

⁴⁶J. Morrocco, Rain of Fire: Air War, 1969-1973, (Boston: Boston Publishing Co., 1985), pp. 131-133.

The most widely used precision-guided weapon was the Paveway family of laser guided bombs. On 10 May, 1972 32 F-4s attacked Hanoi's Paul Doumer Bridge, located close to Hanoi. The bridge was within sight of Gia Lam airfield, its loss would disrupt rail and vehicular traffic in the area, demonstrate the accuracy of the new weapons, and have a psychological effect on the North Vietnamese. Pilots dropped 29 LGBs and heavily damaged the bridge.⁴⁷ Air Force Major General Eugene L. Hudson, 7th Air Force Director of Intelligence, asserted that "laser-guided bombs... revolutionalized tactical bombing."⁴⁸ However, his comments can be expanded, the true importance of precision guided weapons was that they allowed tactical aircraft to participate in a strategic bombing campaign.

H. SUMMARY

In this brief examination of air power in past conflicts, it is obvious that its employment did not achieve its potential. However, the history of air power has gradually matured over the past 80 years, and its potency has increased with time. Unfortunately, nuclear weapons dominated our view of military strategy during the past 40 years.

⁴⁷Mark Clodfelter, The Limits of Airpower, pp. 158-159.

⁴⁸Quoted in Mark Clodfelter, The Limits of Airpower, p. 159.

Strategic warfare became synonymous with nuclear warfare, resulting in the neglect of thought about the strategic employment of non-nuclear air power. However, this has not changed the necessity to determine our strategy and to build weapon systems capable of responding to all levels of conflict.

The nuclear weapon should not substitute for the development of a viable conventional strategy in today's environment. The lessons of World War II and the constraints of Korea and Vietnam serve as the basis for a new approach to the employment of air power in a conventional conflict. The final stages of the air campaign in Vietnam heralded the increasing capabilities of air power to dominate the battlefield. Clearly precision guided munitions play a key role in the proper employment of air power in modern warfare. The following chapter examines the employment of air power in the Gulf War, the first conflict with widespread use of precision guided munitions.

III. A SYMBOL OF MATURITY

The air campaign in the Gulf War is the application of Air Power in its purest sense. It is revolutionary in the sense that a few number of bombs achieved an enormous amount of focused, precise destruction. Desert Storm was the first war in which single airplanes were able to fly through to their targets and accomplish what in the past, either could not have been accomplished at all or would have taken literally thousands of airplanes to accomplish. The issue for modern strategists is whether we have entered an era in which bombing alone can create the conditions for victory. If so, modern technology may have finally caught up with nearly a century of theory with profound implications for the future of warfare.

A. THE REAL AND SYMBOLIC VICTORY

The story of what happened in the air during Desert Storm is well known. Beginning in mid-January 1991, coalition air power seized control of the air over both Kuwait and Iraq within a few hours. Air supremacy was evident within a matter of days. In nearly simultaneous actions, air power blinded and deafened the Iraqi leadership, making command and control of Iraqi forces in the field exceedingly difficult. The air campaign attacked and destroyed strategic targets, such as power plants or nuclear facilities, and tactical targets. The

tactical phase was a classic interdiction campaign designed to physically isolate Iraqi surface forces deployed in and around Kuwait. The interesting point of the campaign is that although Desert Storm was conceived as a four-phased campaign, all phases overlapped to the point that they were nearly simultaneous.

The result was that when the ground offensive began in mid-February, it met minimal resistance and quickly swept forward from Saudi Arabia all the way to the Euphrates River. The magnitude of the aerial victory in the context of the overall campaign was revealed by the almost unbelievably low casualty rate suffered by coalition surface forces.⁴⁹

In previous wars, the impact of air power had always been a bone of contention, the issue was an unresolved and unsolvable debate. In the Gulf War, the impact of air power was clearly overwhelming and decisive but similar results may not occur in the next conflict. However, the nature of the aerial victory is a sign of the ascendancy of air power in modern warfare. It symbolizes the maturity of air power and the need for a new paradigm of warfare.

Air power's greatest asset has always been its flexibility: the range, speed, precision and punch of aircraft make them ideal platforms for waging a war of

⁴⁹The total number of coalition casualties during the Gulf War were 331 dead. James F. Dunnigan & Austin Bay, From Shield to Storm, (William Morrow and Company, New York: 1992)

maneuver. Desert Storm demonstrated how a strategic air campaign can paralyze and immobilize a modern industrialized nation. Iraqi communications, transportation, and power generating sites were rendered inoperative. The air war in the Gulf devastated the Iraqi military infrastructure in only six weeks.

Air power achieved the main political goals of the coalition and produced one of the most decisive victories in history. At a cost of fewer than 200 coalition lives, nearly 150,000 Iraqi troops were killed or captured.⁵⁰ At the same time, the number of civilian casualties as well as collateral damage was kept to a minimum. A key player in the Coalition's success was the widespread use of precision guided munitions. They connected the political objectives to military execution with a high degree of reliability. The political leadership enjoyed greater confidence that discriminate force can be applied to accomplish discrete objectives.

B. THE PRELUDE TO OFFENSIVE ACTION

On August 2, 1990, the very day of the Iraqi invasion of Kuwait President Bush declared a national emergency to address the threat to the national security and foreign policy of the United States posed by the invasion of Kuwait by Iraq.⁵¹ The

⁵⁰James F. Dunnigan and Austin Bay, From Shield to Storm, (New York: William Morrow and Co., 1992), p. 145.

⁵¹Executive Order 12722, 02 August 1990.

president accompanied his words with action. Within a matter of days a rapid mobilization and deployment of forces into the region began.

Two carrier battle groups, led by the USS Independence (CV-62) and the USS Eisenhower (CVN-69), were already on station in the Gulf area. On the way were units of the Army's 82nd Airborne Division and F-15s from the Air Force's 1st Tactical Fighter Wing, by 7 August they had arrived in Saudi Arabia. Other U.S. and Coalition forces quickly followed in the crucial six month buildup of Desert Shield.

The Navy carriers on station and the Air Force's 1st Tactical Fighter Wing could defend Saudi airspace, but their offensive-strike capability was limited. The ground forces in the region were no match for the Iraqi armored divisions poised on the Kuwait-Saudi border. Of necessity, the Coalition's initial strategy was defensive.

During the six months leading up to the war, many things that would have presented problems if the conflict had occurred earlier were fixed. The transfer of personnel to the theater provided the combat forces with access to key technical and maintenance skills. Personnel for critical slots were brought into the region and maintenance and supply units had time to be brought up to wartime strength. However, once the necessary assets for offensive action were available, the initial defensive strategy became offensive.

C. THE AIR WAR IN THE GULF

The Coalition's policy shifted from waiting for sanctions implemented against Iraq to work to taking the strategic offensive. On January 23, 1991, General Colin Powell succinctly summarized the offensive strategy selected by the coalition:

Our strategy to go after this Army is very, very simple. First we're going to cut it off, and then we're going to kill it.⁵²

The issue at hand was how to seize and exploit the initiative.

The plan to take the strategic offensive was broken into four phases. The first three phases called for an all out air campaign against Iraq. Postwar accounts describe the plan:

Phase One would be an air attack on Iraqi command, control, and communications, attempting to sever Saddam in Baghdad from his forces in Kuwait and southern Iraq. Simultaneously airpower would destroy the Iraqi Air Force and air defense system [as well as] Iraqi chemical, biological and nuclear weapons facilities.

Phase Two would be a massive, continuous air bombardment of Iraqi supply munitions bases, transportation facilities and roads, designed to cut off the Iraqi forces from their supplies.

Phase Three would be an air attack on the entrenched Iraqi ground forces of 430,000 men and the Republican Guard.⁵³

⁵²Excerpts from Pentagon Briefing on 23 January 1991 reprinted in Andrew Rosenthal, "Pentagon is Confident on War," The New York Times, 24 January 1991, p. 1.

⁵³Harry G. Summers, Jr., On Strategy II: A Critical Analysis of the Gulf War, (New York: Dell Publishing, 1992), p. 195.

The fourth phase was the ground attack into Kuwait, but clearly the emphasis was on employing Coalition air power against Iraq.

In the early hours of 17 January, complete tactical surprise was achieved in a coordinated attack delivered by Tomahawk cruise missiles, aircraft from the USAF, USN, RAF, RSAF, and helicopters from the US Army. The attack was supported by a large scale electronic warfare effort to disrupt Iraqi radars and communications. Integral to the first two steps of the plan, and a major departure from past air campaigns, was the widespread use of tactical aircraft with precision guided munitions to achieve a strategic result.

The sea launched cruise missiles delivered 1,000 lb warheads against the nerve centers of the Iraqi defense system. The targets were command posts, ground control headquarters and radar stations. The arrival of the Tomahawks stimulated the Iraqi surveillance and surface to air missile guidance radars, thereby disclosing their positions to air launched anti-radiation missiles.

F-117As, operating at night without escort, made precision attacks against strategic installations in Baghdad. The aircraft can carry two laser guided 2000lb bombs and is officially a tactical aircraft. It illuminates a target by laser, and then delivers a bomb onto a specific point within the illumination producing weapon accuracies of one to two feet. The 36 F-117As deployed to the Gulf flew 2 percent of

the bombing missions but hit over 40 percent of the strategic targets.⁵⁴

Elsewhere, packages of USAF F-111s, F-15s, USN A-6s, A-7s, and F/A-18s attacked secondary command and control positions and air defense units throughout Iraq. Again, the strike planners relied on precision guided munitions, to such a degree that over the course of the air campaign, Coalition aircraft conducted 9,117 strikes with PGMs. This accounts for 20 percent of the total bombing missions, 8 percent of the bomb tonnage and about 30 percent of the damage.⁵⁵ Never before in a conflict had an air campaign relied upon such a widespread use of precision guided munitions

The strike aircraft were closely supported by electronic warfare aircraft. USAF EF-111As, EC-130s, and USN EA-6s disrupted surveillance radars, communications between ground controllers and fighters, the guidance of surface to air missile systems. Iraqi radar operators increased their transmitter's power as they attempted to break through the jamming. This effort only made them more vulnerable to attack from anti-radiation HARM missiles.

The entire air assault was coordinated by E-3A AWACS aircraft and guided by a single air tasking order. Throughout the period, Coalition fighters flew protective sweeps and

⁵⁴James F. Dunnigan and Austin Bay, From Shield to Storm, p. 161.

⁵⁵Gulf War Air Power Survey (GWAPS), Table 19-3.

patrols. The result was that within 24 hours the Coalition achieved control of Iraqi air space and through nearly simultaneous actions, air power blinded the Iraqi leadership. Phase one of the air campaign was complete in record time.

Although Desert Storm was conceived as a four-phased campaign, the first three phases overlapped to the point that they were nearly simultaneous. The results of the coordinated air campaign was that when the ground offensive began in mid-February, it met with minimal resistance.

D. SUMMARY

In the Gulf war, the impact of air power was clearly decisive. Its contribution to the overall victory was such that the ground campaign quickly swept from Saudi Arabia to the Euphrates River in 100 hours with an unbelievably low casualty rate. At long last, air power lived up to its potential and fulfilled the promises made by the early prophets of air power.

For an air power advocate, the real breakthrough in the war was the extensive use of precision guided munitions against targets they are effective against. Even though precision guided munitions were employed during the Vietnam War, with a few exceptions, there just were not that many targets that an accurate bomb was going to make a difference against. The importance of Air Power in future conflicts will

be determined largely by whether decisive precision targets will exist.

Before I push the case for air power too far, the need for precision targets highlights some of the controversy that exists over whether air power alone can win the war. A special circumstance existed that made possible the success of air power in the Persian Gulf. The terrain in the Persian Gulf is nearly ideal for offensive air operations. It is nearly perfectly flat with little to no vegetation for an enemy to hid in. This made the strike planner's job much easier. Intelligence assets were able to locate and identify fixed targets with relative ease. Unfortunately, this condition is not a constant throughout the world, an obvious example is the terrain found in the former Yugoslavia.

Also, the hunt for the Scud missile launchers highlighted another issue that may limit the effectiveness of air power in a future conflict. Precision guided munitions allow an aircraft to be more effective against targets the pilot can find. Unfortunately, there is still a problem with finding the target in the first place. A problem exists in finding mobile targets with current intelligence assets, even with the given terrain advantages found in the Gulf region.

The elusive nature of the Scuds will convince any future opponent to increase their inventory of mobile systems. Unless we pay particular attention to this issue and improve our intelligence capability to find relocatable targets, air

power may be less decisive in the next conflict. This will become increasingly evident if strategic targets are made mobile. The performance of air power may be restricted because intelligence simply may not be effective enough.

Even in the face of the previous limitations to air power, it is now obvious bombing alone can win a war. There is no longer any doubt that technology has finally validated air power theory and that one can suggest that air power will play a dominant role in modern war. However, it should not be forgotten that the air war will be part of a much larger, land, sea and air offensive. In this context, the next chapter examines the role U.S. Naval air power can play because of the existence of precision guided munitions.

IV. THE IMPACT ON NAVAL AIR POWER

The end of the Cold War has markedly changed the emphasis in all warfare areas. Regional power projection has taken on increased importance since the decline of the Soviet Union. As recently as five years ago, Anti-Submarine Warfare (ASW) was the primary warfare area emphasis for the United States Navy. The U.S. Navy's priorities have changed, the spotlight now shines on a different warfare specialty. The collapse of the Soviet Union has diminished many warfare areas which were specifically tuned to the Soviet threat. A reexamination of future scenarios which the Navy may face, has brought power projection, or Strike Warfare to the forefront.

The capability of the fleet to project power to foreign shores has grown in recent years. Early capabilities of naval fleets to project power were limited to the range of the guns on a given naval platform. World War II introduced fixed wing aerial strike warfare. Battle fleet commanders could now use carrier based aircraft to deliver ordnance on foreign shores. Although Doolittle's raid on Tokyo achieved more for U.S. morale than it did in a tactical sense, it underscored the capability of carriers to strike deep and deliver ordnance on enemy territory. The ability to attack foreign shores without occupying territory highlighted the versatility and autonomy

of the aircraft carrier and its embarked airwing and marks the origins of naval air power.

Since the Second World War the fleet has invested considerable resources in fixed wing aircraft for power projection. This effort has resulted in an impressive ability to deliver ordnance, both conventional and until recently nuclear, on enemy territory. Equally important, this capability was independent of any host nation support. Since World War II, the Navy has produced a proud legacy of fixed wing attack aircraft.⁵⁶ Today, the F/A-18 and the A-6, with their myriad of munitions, are the mainstay of the fixed wing attack community.

In addition to the impressive capability of fixed wing assets, the Navy has developed another method of delivering ordnance on target, the Tomahawk Land Attack Cruise Missile (TLAM). The development of the cruise missile was not a novel concept. The idea of a cruise missile is as old as the German V1 rockets of WWII. The concept of a long range unmanned autonomous strike vehicle impressed many U.S. war officials. Immediately after the war, the United states commenced an aggressive cruise missile development program of its own.

⁵⁶The first dedicated attack aircraft was the A1-D introduced into the fleet in July of 1944. The next attack aircraft was the A3-D. It was introduced into the fleet in March 1956. The A4-D1 was introduced into the inventory in October 1956. The A-6 was introduced into the fleet in April 1960. In the spring of 1968 the Navy introduced the A-7A. The Navy's newest attack aircraft, the F/A-18 was introduced into the fleet in May 1980.

Using the German rockets as models, the Navy developed two cruise missiles of it's own, the Regulus I and II. Although cruise missiles were kept operational into the early 1970's, they lacked the operational reliability and the accuracy which ballistic missiles offered and were subsequently discontinued.⁵⁷

The new generation of cruise missiles (TLAM's and TASM's) have slowly evolved into weapon systems which can accurately deliver substantial ordnance packages to ranges of approximately 600 miles.⁵⁸ Although they had been introduced into the fleet in the early 1980's, cruise missiles remained untested in combat for almost ten years. The first use of cruise missiles in combat took place in Iraq on January 16, 1991. Cruise missiles, along with F-117 stealth aircraft were used during the opening salvos of Desert Storm to attack command and control headquarters and key governmental installations. Although the effectiveness individual cruise missile attacks are still being evaluated, the value of the cruise missile as a power projection weapon is indisputable.

⁵⁷Ronald Huisken, The Origin of The Strategic Cruise Missile (New York: Preager, 1981). p. 17.

⁵⁸The Tomahawk cruise missile has two conventional warhead variants. The conventional missile warhead is a 1000 lb Bull Pup warhead. In addition to the conventional warhead, the missile can also deploy a submunition package. The missile flies a preprogrammed course placing the warhead on target with great accuracy or deploying a bomblet package over a designated area.

Advanced unmanned systems complement advanced manned systems. Some targets are more sensitive to a weapon's accuracy, others to a weapon's payload. Henry S. Rowen outlined the uses for both weapon systems; "their use [missiles] should presumably be reserved for critical periods for targets especially difficult for aircraft to handle. The cheaper missiles can be made, the less binding the constraint. Aircraft should be assigned principally to 1) targets with low expected attrition, 2) targets which require large delivered payloads, and 3) targets which have some location uncertainty."⁵⁹ The true issue, from an operator's perspective, is to assure a target's destruction or render it inoperable with as little risk as possible. The result is that the selection of weapons for a target is dependent upon that target's defenses. The primary advantage of precision guided munitions (PGM's) is they can destroy a target with a minimum of weapons. In essence they exploit the economy of force maxim of warfare. The importance of this fact is relevant to naval air power. PGM's question the reasons why naval air power is not an integral portion of any conventional strategic air campaign. The issue of the limited fire power available to naval air power, because of a ship's magazine capacity, is no longer valid. Naval air power can make an important contribution to any future strategic bombing

⁵⁹Henry S. Rowen, The Future of Cruise Missiles, (Marina del Rey, California: Pan Heuristics/RDA, 1980). pp. 21, 23.

campaign; in some cases it may be the only way to get the job done.

A. THREAT SCENARIOS

In both the fixed wing and cruise missile realm, the "threat" has played an important role in the development of weapon systems. The Cold War fueled the need for the Navy's development of attack vehicles. The current inventory of aircraft and cruise missiles reflects the difficult task of penetrating the Soviet Union's anti air warfare (AAW) systems and delivering ordnance on Soviet soil. For example, the A-6 is designed to be an all weather, day or night strike aircraft. It was designed to penetrate Soviet AAW defenses by flying a low, terrain hugging profile in any type of weather. Initially, the cruise missile was developed to compete with the Soviet anti-ship cruise missile. Later, its role was expanded to include a land attack version. Because of the diminished threat from the Commonwealth of Independent States (CIS), the U.S. Navy can no longer hinge its entire threat projections or procurement strategy on the familiar mission of power projection into the Soviet Union.

The old strategy dealt with the Soviet Navy and mainland air defenses. The new strategy must focus on contingency operations against an assortment of enemies, in any region of the globe. Although there are no direct military threats to

the United States, threats to our national interest are increasing in many regions of the globe.

Although the need to project power deep into the Soviet Union is no longer a pressing military requirement, many aspects of the power projection problem have remained the same. Much of the equipment which the CIS produced has been sold to other countries, many of them unstable "third world" nations in volatile regions of the world. Additionally, the proliferation of Western advanced weapon systems compounds the problem.

None of these countries or any of the theorized third world scenarios present the vast array of AAW systems deployed in the former Soviet Union. However, many of these countries already possess enough pieces of the old Soviet AAW network to complicate an otherwise easy strike warfare mission. The current economic conditions throughout the former Soviet Union lend credence to the stipulation that some of the more up-to-date models may be up for sale as well. So, although the Soviets are a diminished threat, the proliferation of their equipment and Western equipment has created other viable threats throughout the world.⁶⁰ The need for a robust power projection capability has not diminished, in fact many contend that it has increased.

⁶⁰According to Janes Weapons Systems, some of the Soviet AAW systems which are in third world inventories include: SA-5, CIS and Syria; SA-6, CIS and "others"; SA-2, CIS and "others"; SA-3, CIS and others.

In any anticipated power projection scenario, the Navy will rely on both strike aircraft and cruise missile assets presumably used in a complementary way dependent on the scenario. The uncertainty and instability inherent in many regions requires extensive military planning for contingency strike missions. If the basic guidelines from the Gulf War remain, strike missions must be planned for maximum effectiveness against the target and equally important, must minimize collateral damage to civilians.

Missions for both of these weapons systems must emphasize flexibility and accuracy in order to handle a wide range of contingencies in a variety of environmental and political climates. Strike missions will be conventional responses with limited military objectives. They will be required to engage high tech mobile defenses, and will require increased accuracy to minimize U.S. losses. Once the decision to use strike forces has been made, appropriate targets could include enemy C3 assets, leadership, supporting military industries, as well as conventional military targets. In addition, strike forces could be tasked to perform preemptive strikes designed to incapacitate an aggressor's offensive military capabilities before hostilities begin.

Another mission which will occupy a prominent role in any strike planning folder is the destruction of fixed or relocatable targets of a strategic nature. Ballistic missile launchers, both mobile and fixed, and nuclear, chemical and

biological weapons processing plants are two of the most prominent. A third strike mission would be the destruction of enemy shipping. For the foreseeable future, fixed wing attack aircraft and cruise missiles will be the basis for the Navy's power projection forces.⁶¹

This paper examines the technologies and developments which effect these two weapon systems. Emerging technologies significantly influence these weapon platforms; however, the political and economic climate may be a greater influence on each of these systems than technology. This evaluation considers the cost of these new systems in only a broad sense. Predicting future military appropriations is an impossible task; however, cost ratios with respect to existing technologies can be considered. The technological innovations which are examined are all evolutionary vice revolutionary in nature.

B. CARRIER BASED STRIKE AIRCRAFT

U.S. military strategy is based upon three fundamentals: deterrence, a rapid response to crisis and alliance solidarity. The U.S. Navy supports a forward offensive strategy to achieve both a deterrent and a quick reaction strike capability. Specifically, one or several carrier

⁶¹From an interview with Dr. James Brooke, Strategic Planning Departmenthead, Convair Cruise Missile Division, by LCDR Sam Perez, 24 February 1992, Monterey, California.

battle groups would deploy to a region which experienced a crisis affecting U.S. interests. The inherent flexibility of a carrier battle group to conduct operations against a belligerent gives the United States a credible response to any regional crisis located near a coastline (within approximately 1000 miles) without having to rely on basing agreements.

The chief combat functions of a carrier battle group include "attack against land targets...as well as air superiority in the area of operations." The battle group commander has two strike options at his disposal, a Tomahawk Land Attack Missile (TLAM) or an air strike made by the airwing. Aviation has the unique ability to concentrate firepower rapidly at the critical place and time, which allows exploitation of the economy of force maxim. The two strike systems allow a commander to utilize the strengths of each one in a combined arms effort. The advantages of TLAM against heavily defended fixed point targets will be discussed later. The airwing's strength is to penetrate a moderately defended area or point target with assured destruction. The primary advantage lies in the myriad of weapons the strike aircraft can deliver, which can be tailored to assure a target's destruction.

In order to conduct air operations, the carrier's embarked airwing totals around 90 aircraft, with approximately 24 fighters (F-14), 24 light attack (F/A-18), and 10 medium attack (A-6) aircraft comprising the strike force.

Antisubmarine warfare, electronic warfare, tankers and airborne early warning aircraft support the strike force and make up the remainder of the airwing. During a regional crisis, the carrier airwing is undoubtedly the most visible and potent response possessed by the United States and the least intrusive until called into use.

The carrier battle group will continue to remain an integral part of any power projection operation. The concern is how well the airwing can perform the strike mission in the future. An assessment of the Navy's carrier based air strike capability concentrates on the F/A-18 and its associated weapon systems. The A-6, for the most part, is ignored since it represents older technology, but the impact of the aircraft's age on the strike mission is discussed in detail.

The F/A-18 Hornet is an all weather multi-mission single pilot high performance fighter/attack aircraft. The pilot operates the aircraft with the aid of a digital flight control computer and a mission computer. The Hornet has a top speed of 1.8 Mach, thanks to its twin 16000 pound thrust General Electric F404 engines, and can sustain high aerodynamic loads in excess of 7 G's. The dual nature capability of the aircraft equates to a better war fighting capability and increases the flexibility of a response to any threat.⁶²

⁶²Kenneth Kendall, "Electronic advances on the F/A-18 Hornet," National Defense, May-June 1983, pp. 22-23.

Unfortunately, this dual capability is attained by sacrificing combat range.

The APG-65 radar is the heart of the weapon system. It can track multiple airborne targets and provide highly accurate release solutions for the myriad of air to ground weapon systems employed by the Hornet. The APG-65 is a digital radar able to provide the pilot with navigational and targeting information. The radar employs a high pulse repetition frequency (PRF) for a long range search capability at ranges in excess of 100 miles and ranging for weapons delivery against targets within 50 miles.⁶³ The combination of the F/A-18's sensors, the laser spot tracker, the forward looking infra-red (FLIR) and the APG-65, allows the pilot to automatically compute air to surface ranging data for targets obscured by weather or darkness.

Self-protection and warning equipment outfitted in the F/A-18 include: the ALR-67 radar warning receiver, the ALE-39 counter measures dispenser, and the AN/ALQ-126 defensive electronic countermeasures system. The ALR-67 detects radar guided threats and displays them visually to the pilot. The other systems operate in a variety of ways to increase the aircraft's survivability in a high threat environment.⁶⁴

⁶³James B. Shultz, "Marines Put F/A-18's to the Test," Defense Electronics, November, 1983, p. 111.

⁶⁴Ibid, p. 110.

The most important electronic advancement incorporated in the F/A-18 is the stores management system (SMS) which controls the aircraft's deployment of its vast array of weapons and external stores. The system is a state of the art digital avionics computer with the flexibility to add future weapon systems with only a software change. The SMS not only allows the pilot to release munitions, but it does it in an aerodynamically balanced manner. The system maintains an inventory of stores, types, locations, quantities, status, special conditions for release sequencing and displays this information to the pilot. The result is a reduction in the pilot's work load in flight through automation in the control of a weapon's fuzing, release sequence, and any interface requirement with a smart weapon.⁶⁵

The Hornet as a package is an impressive array of sophisticated technology, but several criteria must be explored prior to a judgement on effectiveness. One primary consideration of the effectiveness of a strike aircraft is the range the aircraft can fly with a specific payload. The effectiveness of PGM's suggest the lower number of weapons represent the most appropriate point for comparison. Other important considerations include survivability, reliability and maintainability. The combination of these criterion

⁶⁵Kenneth Kendall, pp. 22-23.

produce the overall effectiveness of an airwing's ability to conduct a strike mission.

The major drawback to the Hornet is its strike radius, without any inflight refueling. Once ranges exceed approximately 600 miles the F/A-18 requires inflight refueling to execute its mission without reducing its payload. In the attack mission the limited range is augmented with the use of inflight refueling and/or external fuel tanks. The aircraft's capability to deliver munitions accurately compensates for its ordnance quantity limitation. Precision guided munitions compensate even further for the Hornet's range limitations.

A comparison in the maximum ranges for each of the two primary attack aircraft, on a high-low-high profile with 1000 pound Mk-83 bombs, yields the following information:

<u>LOAD</u>	<u>F/A-18</u>	<u>A-6</u>
4 Mk-83	706	1000
6 MK-83	630	950
9 Mk-83	495	775
12 Mk-83	359	600

Source: U.S. Congressional Budget office, Costs of Modernizing the Navy's Carrier Based Air Forces, P. 43.

An immediate observation is that the A-6 has more range than the F-18 at any weapons load. However, even though the Hornet cannot achieve the ranges of the A-6, it does have an impressive range with either 4 or 6 Mk 83s. The affect of the Hornet's range limitation is much mitigated with today's inventory of precision guided munitions which equate to one

bomb per target and allow us to utilize the lowest number of weapons in the loadout.

The Hornet's survivability and agility/maneuverability is a marked improvement over the performance of the A-6. The combination of the aircraft's strengths make the Hornet the most flexible and potent asset in the attack role. The current problems with the A-6's service life without any replacement in the near future imply a heavier reliance will be placed upon the F/A-18 to complete the strike mission. Unfortunately, the aircraft was not designed to have the range or bad weather penetrating characteristics of a medium attack aircraft. The range limitation is the most serious of the two problems. If the Navy is to retain a deep strike capability and participate fully in a strategic air campaign, a replacement for the aging A-6 is required if the Navy is maintain a credible long range strike capability against targets which a TLAM is ineffective.

The combined effect of technology upon the carrier airwing, both now and in the near future, has created a potent strike force able to complete surgical strike missions. Naval aviation is clearly a major player in the completion of any strike mission today. The airwing can complete the mission in the future only with the continued development of priority weapon systems. The development of new strike aircraft is necessary only for the medium attack role. The F/A-18 can complete the light attack mission for the next 20 years

without a replacement, but the A-6 needs a replacement now. Exactly when a replacement will become operational is anyone's guess, but it should exploit the advantages offered by stealth technology.

Today the aircraft delivered weapons for use in land attack consist of several technologically advanced weapons. Walleye (an electro-optically guided glide bomb), Laser Guided Bombs, the Stand Off Land Attack Missile (SLAM: which incorporates GPS for mid-course guidance and an IR sensor for terminal guidance), Shrike and Harm (anti-radiation missiles-ARM'S), and others make up the current inventory of smart weapons which can be used in a strike mission. The scientific community developed the technology incorporated by these weapons in the 1960's and 1970's and have worked ever since to improve their capabilities. The systems which exist today represent evolutionary "state of the art" improvements incorporated in the 30 year development of these technologies.

The weapons in the inventory today all have their drawbacks. LGB's are unusable against a weather obscured target and their effectiveness is degraded by haze and smoke. Any electro-optically (EO) guided munitions, like Walleye, has the same weather restrictions as LGB's. An added complication is the issue of Walleye's reliability which is questionable.

The newer EO weapons, like SLAM, do have increased reliability but their small numbers in the inventory makes the Walleye the primary EO system. However, the assembly line for

Walleye I and II has been closed for some time and weapons in the inventory have been on the shelf for quite a while, some since the mid-1970's. Experience with Walleye suggest a major limitation exists for sophisticated weapons; shelf life and reliability are inversely related. The problem becomes more severe and will affect other "smart" systems in the future if budgetary constraints force a longer shelf life. Solid state electronics and on the shelf testing can reduce the problem, but the rate of failure for any given weapon will increase with age.

Developments in the tactical aircraft and sophisticated weapons have been incremental rather than revolutionary. However, the incremental developments in the field of weapons technology, by the very magnitude of their increased capability, do have a revolutionary impact upon warfare. The key contributing technologies are microelectronics, aerospace, composite materials, energy, and telecommunications. Developments within these fields include: powerful imbedded computers, the size of a small chip, which will be standard in modern weapon systems; significant aerospace gains, to include extension of range, duration of flight, reliability, stealth capabilities, stand-off detection, and stand-off targeting at substantially greater ranges. One of the most dramatic improvements has been the in the area of weapons accuracy, the ability now exists to target precision guided munitions at long ranges with pinpoint accuracy.

In broad concept, the new weapon systems employing these third generation technologies are able to inflict substantial damage upon any opposition. The combination of increased range, accuracy and penetration capabilities of new weapon systems enhances military effectiveness at the strategic and tactical levels of warfare. Pinpoint accuracy and significantly enhanced lethality reduces: aircraft sorties (which increases survivability), the amount of ordnance required to ensure a target's destruction, and associated logistic requirements. The jump in capability mandates a review of current tactics and strategy to exploit these new weapon systems and stealth technology properly. One aspect is certain, the post 1992 generation of weapons will include a new family of gravity bombs, some with guidance systems, one or two new weapons for stand off attacks from both point and area defenses and a small family of antiradiation missiles for the suppression of enemy air defenses (SEAD).

The application of the Global Positioning System (GPS) in both aircraft and munitions is a dramatic increase in existing capability. Current aircraft navigation systems drift an average of 0.5 to 1.5 miles per hour. The systems today can be updated inflight but the drift remains internal to the system. GPS equipped aircraft have an accurate drift free navigation system and have a significant edge in the successful execution of any strike. GPS assists a pilot in

locating a target and allows for the attack of known fixed targets by bombing strictly on coordinates.

The largest drawback to GPS is that the system requires about 20 seconds to establish a geographical fix, about 20 seconds. The GPS signal from the satellites is constant but current hardware updates geographical positions periodically and not constantly. The difficulty is its inapplicability to short time of fall/flight ordnance. The current programs under development include placing GPS into free fall gravity bombs and cruise missiles. Munitions release above approximately 20,000 feet would be required to meet the 20 second requirement. Unfortunately naval tactical aviation does not currently use high altitude bombing as a primary tactic. A separate issue is the subject of mobile targets which require a different type of sensor to obtain precision accuracy.

The current projects under joint development are the Joint Standoff Weapon (JSOW) and the Joint Directed Aided Munitions (JDAM). The two programs incorporate state of the art guidance technology and are evolutionary developments of LGB's and Walleye. The infusion of technology into the munitions field enables these new precise weapons to utilize more than one sensor to discriminate a target. The result is an increased all weather capability which negates the degradation of the previously mentioned systems to weather, haze and smoke.

The JSOW is a non-powered inertial aided munitions. Navigation is provided by a GPS aided ring laser navigation system and an onboard digital computer.⁶⁶ The weapon system has two payloads. Either a unitary warhead or a series of BLU-108 submunitions can be delivered to a target. Terminal guidance is anticipated to be an Imaging Infrared seeker. The anticipated standoff range keeps the delivery aircraft out of range of area and point air defense systems. The baseline model consists of two versions which will deliver submunitions into an area to destroy mobile targets.

The JDAM program is simply a kit designed to augment the current gravity bomb family.⁶⁷ The program incorporates inertial navigation to improve weapon accuracy if a target's position is known. Short time of fall weapons will use a GPS update from the delivery platform but does not use GPS for navigation. Instead, a ring laser gyro provides inertial navigation to the munitions. The resulting system drift is negligible with a short time of fall release, current releases rarely exceed a 10 second time of fall. The significant improvement is the incorporation of a second sensor into the weapon. Currently a variety of sensors are being examined, their cost effectiveness appears to be the primary decision

⁶⁶AIRTEVRON FIVE Briefing Notes, "Concept of Operations for the Joint Standoff Weapon System," November, 25, 1992.

⁶⁷The information regarding JDAM is drawn from CAF 401-91-I-A, Joint CAF/USN Requirements Document for Joint Direct Attack Munitions (JDAM) Program.

factor. The four most prominent are either a millimeter wave, a synthetic aperture radar, a conventional radar, or an infrared sensor.⁶⁸ The incorporation of any of these sensors allows a delivery against a known target obscured in bad weather conditions or by smoke.

The weapon system is designed for missions against a target defended by moderate close in anti-aircraft weapons. Currently, operational testing of JDAM is achieving accuracies similar to Tomahawk's. Additionally, JDAM's warhead possesses similar performance characteristics to Tomahawk's. The system allows the planner a low cost option to TLAMs for use against lower threat targets, the intent is to reserve TLAMs for the heavily defended, high threat, targets. The logic for this approach is found in the cost comparison between the two weapons.

Phase I of JDAM is the development of the basic guided munitions and has been completed with a cost per copy of 40,000 dollars.⁶⁹ Phase II and III, the development of a new high explosive and the incorporation of a second sensor, are still in the formative stages but the estimated cost of all three stages of development is estimated at 100 thousand dollars per copy. On the other hand, the average cost of a

⁶⁸George Leopold, "Military Focuses on Sensors, Target Recognition," Defense News, February 8-14, 1993, Vol. 8 No. 5, pp. 12-13.

⁶⁹CAF 401-91-I-A, p. 3.

Tomahawk is between \$800,000 to \$1,000,000. On a cost per weapon basis, JDAM is clearly the weapon of choice. The caveats to this point are the possibility of aircraft attrition must be minimal and/or the cost of a TLAM is not significantly reduced.

The most impressive advances in weapons technology is in the area of smart weapons. The necessity to penetrate an enemy's air defenses is getting more difficult as defensive systems become more advanced. The evolution of smart precision guided weapons and aircraft have been to counter these higher technology defensive systems. Today, the capability exists for aircraft to create a sanctuary within which they can operate in this hostile environment. The development of naval air power has been reactive to the increased capabilities in defensive systems. The associated technology has developed in a logical and incremental manner to encompass the current "state of the art" systems. The capabilities the airwing possesses in precision accuracy, and will possess in the future, ensures that naval tactical aviation remains a participant in any future strike scenario.

C. CRUISE MISSILES

Many Navy officials, both civilian and uniformed, realized a requirement for cruise missiles in the 1960's. As early as 1966, then Secretary of the Navy Paul H. Nitze agreed to a proposal submitted by Captains Zumwalt and Bagley which laid

the groundwork for the Navy's eventual adoption of the Submarine Launched Cruise Missile (SLCM).⁷⁰ However, the leadership within the Navy was undecided on the idea of a cruise missile. Since WW II, the "carrier admirals" had risen to ascendance and had pushed the carrier and its associated airwing as the primary weapon system in the Navy. The submarine forces, with the advent of nuclear power and submarine launched ballistic missiles, were gaining new stature within the Naval hierarchy. The "surface admirals" were in no position to influence significant projects without the aid of either of the other two factions or another powerful driver.

The actual conception of the Tomahawk cruise missile was a result of the collaboration between the Chief of Naval Operations, Admiral Elmo Zumwalt and Defense Secretary Melvin Laird. The CNO wanted to develop a tactical anti-ship cruise missile while the Secretary of Defense wanted to develop a strategic cruise missile to use in the Salt negotiations.⁷¹ New technological developments enabled the new missile to achieve greater ranges and accuracies than the older 1950's versions. The new gas turbine engine technology enabled

⁷⁰Robert J. Art and Stephen E. Ockenden, "The Domestic Politics of Cruise Missile Development, 1970-1980," in Cruise Missiles Technology, Strategy, Politics, ed. by Richard K. Betts (Washington, D.C.: The Brookings Institution, 1981), p. 381.

⁷¹Art and Ockenden, p. 384.

engineers to use cheap light turbofan or turbojet engines which could achieve ranges in excess of 2000 kilometers. In addition, the new microelectronics technology in aircraft guidance and inertial navigation was easily adaptable to the new missiles and enabled the missiles to reach accuracies which could not be achieved by any other existing missiles. These developments made the new missile extremely attractive to both the Secretary of Defense and the CNO. As a result, the Secretary of Defense directed the development of the strategic cruise missile in June of 1972. Even in the early stages of development, cruise missile rationalization was a delicate matter. When asked whether there was a threat driving the development of the cruise missile, Robert N. Parker, Principal Deputy Director of Defense Research and Engineering, answered: "No threat, but a real need considering both the tactical and the strategic requirements."⁷²

D. DESERT STORM CRUISE MISSILE LESSONS LEARNED

Although Tomahawk cruise missiles had been deployed to the fleet for several years, Desert Storm was the first time the Navy fired TLAMs in combat. Even though the operational tests were extremely promising, few commanders had the confidence or practical knowledge necessary to employ Tomahawk effectively.

⁷²U.S. Congress. Senate. Committee on Armed Services. Research and Development Subcommittee, 94th Cong., 1st Sess., 17 March 1976, pp. 6201.

Commanders lacked confidence in the cruise missile and its ability to deliver ordnance accurately.⁷³ They had to be convinced that cruise missiles could be used effectively under real combat conditions. Initially, many commanders and their staffs were reluctant to use cruise missiles against high priority targets unless sufficient numbers were allocated.⁷⁴ Tomahawk's performance during Desert Storm permanently erased any doubts. Although TLAM employment highlighted both the strengths and weaknesses of the new weapon system, the strengths far outweighed the weaknesses. Current improvements to TLAM are using these lessons learned to guide future upgrades to cruise missiles. These lessons can be grouped into three categories, mission planning, missile utility, and battle damage assessment.

The sudden Iraqi invasion of Kuwait highlighted a crucial weakness in cruise missile employment, the time delay of mission planning. There were no missions planned for either Kuwait or Iraq at the beginning of the conflict.⁷⁵ Neither of the Cruise Missile Support Activities (CMSA) had the required Terrain Contour Mapping (TERCOM) or Digital Scene Mapping Area Correlator (DSMAC) scenes for mission planning. As a result, the first TLAM missions could not have been

⁷³From an interview with LCDR Sam Perez, 02 June 1992, Monterey, California.

⁷⁴Ibid.

⁷⁵Ibid.

delivered in theater promptly, had not the opening of hostilities been delayed for almost six months.⁷⁶

A separate issue associated with planning cruise missile strikes during the Gulf War was the lack of expertise available to the on-scene commander. Few people on CENTCOM staff had any practical experience with cruise missiles. The staff was unfamiliar with either the requirements for a cruise missile strike, or the capabilities of the weapon. Many thought that cruise missiles could be brought to bear immediately. Others believed that cruise missiles were of little or no practical use in the Kuwait theater. Few realized that cruise missile targeting was an extremely complicated process which would require extensive time and resources.

Targeting for any strike mission is a sophisticated process. The first step for any targeteer is a thorough analysis of the mission objectives. The targeteer must familiarize himself with all applicable OPLANs and with the strategic concepts germane to the conflict. The second step is the selection of appropriate targets. Again, this requires a fundamental grasp of both the tactical and strategic objectives. The next step is choosing the appropriate weapon. Weaponers must be consulted in order to determine target

⁷⁶The information is from the notes of a brief by James Adams, LDCR USN, "Strike Warfare Architecture," obtained from LCDR Sam Perez, 6 April 1992, Monterey, California.

vulnerabilities to various weapons. The selected targets can then be matched up to corresponding availability of weapons. Following the selection of the appropriate warhead/weapon, the planner then decides which delivery platform is the most appropriate for the mission. The planner takes into consideration the degree of control required for the mission, whether or not the risk of collateral damage exists and is a significant issue, and to what degree risks to U.S. personnel can be accepted. The strike planner then determines which routes will be used and for cruise missile strikes whether TERCOM and DSMAC assets are available. Target defenses, navigation aides, and launch points must also be carefully considered during this process. The final step in the targeting process is mission assessment. The targeteer must utilize various assets to determine whether or not the attack was successful.

The current method for planning cruise missile strikes involves a complicated procedure which is not controlled by the tactical commander. The procedure requires the coordination and compilation of data by the CMSA. In order for a targeting package to be generated, a unit must request a targeting package from their respective CMSA. The CMSA will then gather data from the Defense Mapping Agency (DMA) for both the TERCOM navigation system and the DSMAC terminal

guidance system.⁷⁷ In order to construct a mission profile, the CMSA must first have the requisite information. They must have accurate terrain maps available to identify the pre-determined points along the missile's flight path and current imagery for DSMAC. If the data is available, the process can be completed in a relatively short period, but it is still a time consuming process. If not, the process may take as long as 30 days to build. Even if the information is on hand, this time requirement places heavy restrictions on the tactical utility of land attack cruise missiles. The cruise missile, as it exists today, is not suitable to every scenario.

The effectiveness of land attack cruise missiles is a function of warhead lethality and terminal guidance accuracy. The precision of Tomahawk combined with the effects of a 1000 lb warhead enables the cruise missile planner to engage a wide variety of targets. However, in order to obtain the required accuracy, each target set must be supported by a specific pre-planned mission.

During Desert Storm, cruise missiles were utilized against command and control centers, electrical power plants, information control and processing facilities, chemical and nuclear processing plants, and other supporting industries, such as oil and production facilities. Although these targets

⁷⁷John Haystead, "Autonomous Weapons-Are We Smart Enough for Them?," Defense Electronics, February 1992, Vol. 24, No. 2., pp 31-32.

were effectively engaged, there were other targets which could not be engaged by cruise missiles.

The dependence of the cruise missile on fixed waypoints for guidance information makes it unable to engage relocatable targets. Because of their mobility, Scud launchers could not be targeted by cruise missiles. In addition to mobile targets, TLAMs were also ineffective against hardened bunkers. Cruise missile warheads lack either the kinetic energy or a sufficiently large warhead to penetrate and destroy hardened personnel bunkers. Further, if the surrounding area is damaged by other strike assets, the DSMAC scene may be damaged or altered, requiring construction of another targeting package.

Another restriction to cruise missile utility is the inability to accurately predict their time of arrival on a target. This restriction prevents a closely coordinated cruise missile and fixed wing strike mission. Instead, the current tactics call for fixed wing strikes to be preceded by a cruise missile strike or they are conducted autonomously.

Another aspect of cruise missile utility is its ability to engage different target sets. Mission planning flexibility and response time were the two of the most important areas which needed improvement during Desert Storm cruise missile operations. Because cruise missile targeting is performed by units which are not directly subordinated to the battle group commander or the even the theater commander, the response

times for mission planning are not necessarily compatible with tactical timeline requirements. The battle group commander must have a system which he can program, target, utilize, and evaluate in a tactical engagement. The system must be flexible enough to respond to changing tactical scenarios, and even fluid strategic requirements. The current cruise missile targeting system is not suited for this type of short term tactical environment.

The agency which supported the bulk of CMSA's cruise missile targeting requirements was the Defense Mapping Agency (DMA). At the beginning of hostilities, only six primary routes were available.⁷⁸ Many of the routes required overflight approval from adjacent countries. In order to support cruise missile operations for Desert Storm the DMA mobilized 3 shifts for round the clock operations. Many of the most desirable routes were unavailable due to lack of terrain features or lack of information. Clearly, this was not a tactically flexible weapons system which would lend itself to theater or battle group level employment. However, the new improvements discussed in the next section enable future cruise missiles to overcome these limitations.

⁷⁸Lengerich, "TLAM Targeting During Desert Storm".

E. TECHNOLOGICAL DRIVERS AND TECHNOLOGICAL ADVANCES

Both the mission planning and the missile utilization problems are being addressed by new technological innovations. The drivers for these improvements stem from a variety of evolutionary technological innovations and upgrades. The first of these innovations is the ability to miniaturize many of the components used in the terminal guidance sensors. The miniaturization of the guidance section decreases the weight of the unit which increases the range of the missile. The second most important area of innovation is engine design and alternate fuels utilization. The final area of improvement lies in the improvement of communications data links.

The most significant and immediate guidance innovation is the addition of Global Positioning Systems (GPS) units to the missile's guidance units. GPS is a satellite based system which derives its accuracy from a cluster of existing navigational satellites. The GPS precursor, TERCOM, requires a certain amount of elevation change to function properly. If the terrain does not have the required variation in terrain contour, alternate routes must be utilized.

The incorporation of GPS will increase overall system accuracy. Most importantly it will reduce the mission planning timeline to as little as 3 hours.⁷⁹ The GPS guidance units are not dependent on these geographic

⁷⁹John Haystead, "Autonomous Weapons-Are We Smart Enough for Them?," p. 32.

limitations and allow the cruise missile to work in areas with flat terrain where radar altimeters do not provide enough discrimination.

Terminal accuracy and flexibility are being improved by a number of other technical innovations. The first of these is the development of Imaging Infrared Radar (I2R). I2R is one of the leading candidates for cruise missile terminal guidance. In addition to its demonstrated accuracy, it is one of the most mature systems in the development queue. It can distinguish between 2-D/3-D features and can also differentiate between various regions and boundaries which are defined by contrasts. Although it is a leading candidate, I2R is affected by weather, and is susceptible to target variability and reference adequacy. I2R, like all of the other contending systems except DSMAC, limits the missile's terminal trajectory.

The second system under consideration is Synthetic Aperture Radar (SAR). This terminal seeker innovation is an all weather unit with a significant range increase over all other systems. In addition to being costly, SAR technology is not as mature as I2R technology, and requires a significant increase in power. It is also limited to specific terminal trajectories. Like I2R, SAR suffers from reference adequacy. The missile's reliability is therefore dependent upon a reflected signal from the target. The nature of the target's ability to reflect the signal influences the range of

acquisition of the target. A reduced range of acquisition decreases the likelihood of a cruise missile acquiring the target.

Laser Radar (LADAR) is a terminal guidance unit which offers a significant increase in accuracy. It will be able to distinguish 3-D and 2-D height specific targets. Like DSMAC, it can utilize terrain elevation. LADAR also offers ease of reference scene preparation. In addition, it offers one of the highest probabilities of acquisition. LADAR suffers from a lack of system maturity and high cost. In addition, LADAR is also affected by weather and is susceptible to high power requirements and stringent cooling requirements.

Real Beam Millimeter Wave (MMW) terminal guidance units are a low cost alternative with limited all weather applications. On the other hand it is one of the least accurate systems. In addition, MMW guidance units have significant target type limitations and increase missile observability.

The final guidance system in consideration for cruise missile upgrades is Forward Looking DSMAC, or DSMAC IIA. This system is a low cost alternative to other systems. In addition to expanding the scene availability and simplifying mission planning, it also reduces diurnal and seasonal launch restrictions. Another advantage of DSMAC IIA is its reliability and the ease of backfit with existing systems.

Like its predecessor, it can be affected by weather or target definition.

The incorporation of either SAR, I2R, LADAR, or MMW guidance units enhances the overall capability of the cruise missile. Tomahawks will be able to engage a larger set of targets with better accuracy. They will be able to engage relocatable targets such as ballistic missile launchers and many other target sets which are not readily supported by digital scene construction. Although they will not be able to penetrate super hardened bunkers, the increased accuracy will enable the missile to destroy critical communications, and power sources leading to and from the bunker.⁸⁰ Additionally, the missile will no longer be restricted to either a land or sea based mission.

The result is the cruise missile will become an even more and capable flexible weapon system. The increased flexibility demands increased operator knowledge and familiarity but it does mean a dramatic reduction in the planning time requirements. The result is that the main restriction to Tomahawk's real time use is no longer applicable.

In addition to increased accuracy, the new guidance units will enable the missile to achieve precise time on top arrivals. By incorporating better navigational data and precise timekeeping capabilities from GPS, the new missiles

⁸⁰Brooke interview.

will be able to achieve precise arrival times at the target. Missions which could not be planned due to imprecise coordination of cruise missile attacks and fixed wing arrival times are now possible. This enables cruise missiles to assume a leading edge strike posture. Cruise missiles can attack enemy air defenses, freeing fixed wing assets for precision bombing missions. This innovation represents a significant capability increase in combined arms strike mission with fixed wing aircraft.

In the area of missile propulsion, two significant innovations offer significant performance improvement for cruise missiles. The first of these is the improvement in engine designs. Light weight engines with increased thrust to weight ratios have increased speed and altitude performance, and improved rates of climb. In addition, the increased performance will enable a significant decrease in fuel consumption. The second innovation is the use of alternate fuels. In conjunction with the improvement in engine performance, alternate fuels will enable the new generation of cruise missiles to achieve ranges in excess of 1000 NM.

In the strategic sense, the increase in range offers a dramatic shift in cruise missiles utility. In addition to current tactical usages, the extended range increases the cruise missile's strategic utility. In all of these areas power projection capabilities and limitations will be an important part of any contingency plan. The increased

performance of the engines makes all but a few regions of the world accessible to cruise missile strikes. Strategically, cruise missiles can be utilized in almost all areas of instability. In the past, rapid power projection capability was centered around the carrier battle group. Today, in addition to tethering carrier battle groups to certain volatile regions of the world, the Joint Staff has now begun tethering cruise missile platforms to certain regions.⁸¹ In conjunction with the carrier air wing, the theater commander has cruise missiles available to plan a contingency operation. The limitation of numbers afloat, or available to a commander, remains an important issue. But the high accuracy of both manned and unmanned weapon systems reduces the impact of this restriction. The theater commander now has available a more potent strategic arsenal.

F. RECOMMENDATIONS

Although these new innovations enable significant improvement to both cruise missile and fixed wing strike aircraft capabilities, their implementation is subject to the ongoing budget battle. In the wake of the Soviet collapse, Congress is less willing to fund costly programs to improve weapon systems which they view as "good enough" and which many lawmakers view as sufficient to handle future threats. The

⁸¹Roy Balaconis, Commander USN, "World Wide Crisis Conference Brief," August 1991, Washington D.C.

current price of 1.3 million per missile is in excess of the targeted price of 0.8 million per missile. Unless massive quantities of the upgraded missile are produced, the projected costs will rise significantly. According to RADM Wagner, the PEO for Cruise Missile Project and Unmanned Aerial Vehicles, the total R&D and procurement costs for the new improvements range from 1.0 to 2.3 billion dollars, plus or minus 50 million dollars.⁸² Although the new cruise missile offers the opportunity to engage the enemy without any risk to U.S. pilots, lawmakers may view the price of the upgrades as too high.

Precision guided munitions innovations enable one weapon system to perform both sea control and power projection roles. In the role of sea control, they enable the engagement of individual ships in heavy background shipping environments. In the land attack role they can overcome many of the disadvantages of current cruise missile/fixed wing weapon systems including relocatable targets, and targets which require faster planning-to-shooter coordination. Although the cruise missile is not a system designed to replace fixed wing strike assets, it can handle a wider variety of missions thus enabling fixed wing assets to be used for more critical

⁸² The information is from the notes of a brief by G.F.A. Wagner, RADM USN, PEO for Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project, "Tomahawk Baseline IV," obtained from LCDR Sam Perez, June, 1992, Monterey, California.

missions. The combination of the two systems provides a rapid, lethal, response to regional conflicts.

The real value of precision guided munitions is their ability to bring a delicate situation under control quickly. Moreover the mere presence of a battle group with the demonstrated accuracy of these assets could deter a potential aggressor. Along with fixed wing assets, improved cruise missiles could delay or deny forward enemy movements. The enhanced accuracy and flexibility makes it an ideal weapon to neutralize enemy air operations and suppress enemy air defenses.

Naval and all other air power assets can now be used to attack strategic targets which were once reserved for nuclear weapons. Although precision guided munitions are not suitable for mass population destruction, they are suitable for striking targets critical to an enemy's military infrastructure. Key production facilities, power production facilities, and most importantly, leaders and key C3 assets are all vulnerable to the new generation of weapons.

Whether or not Congress agrees that the new capabilities are in fact necessary or whether "better is the enemy of good enough" is yet to be seen. One must not forget that no advance in technology yields a permanent advantage; someone will eventually develop an effective countermeasure. Therefore, we must continue to develop and produce advanced conventional weapons and the systems that support them.

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